Appendix C West Sharrard Creek Flood Plain Analysis

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Memorandum

To: Cary Hudson, Walsh Environmental

CC: Grant Gurnee, Walsh Environmental

Julie Ash, Walsh Environmental

From: William P. Ruzzo, P.E.

Date: October 12, 2004

Re: Sharrard Creek At Anvil Points – Hydrologic Analysis

A hydrologic analysis was conducted for Sharrard Creek at Anvil Points to estimate the 100-year flood peak and a hydraulic analysis was performed to evaluate the capacity of the existing Sharrard Creek channel near the shale pile.

The project area is located 7-miles west of Rifle and north of I-70. The location of the shale pile was noted as N39˚ 31' 15" latitude and 107˚55' 00" longitude. Survey cross section information was provided by Walsh.

Results and Conclusions

The results of the analysis are summarized in Tables 1 and 2 presented below. The conclusion of the analysis is that the existing Sharrard Creek channel has adequate capacity for the 100-year flood peak with freeboard.

Hydrologic Analysis

To estimate the 100-year peak flows, regression equations developed by the USGS from three separate reports were used (USGS 1986, USGS 1994, USGS 2000). The regressions were primarily based on watershed area, but one equation also included average watershed slope and another included average watershed elevation. Mean annual precipitation was also a regression parameter, but for other flood frequencies. Mean annual precipitation at the Parachute gage (gage 0909300, USGS 2000), which is the nearest station is 18-inches.

The watershed area, elevations, length and slope were determined from topographic information (Delorme 2004). A summary of the watershed characteristics used in the regression equations is shown on Sheet 1 of the Appendix. Peak flows were calculated for the 100-year recurrence interval and for the 95% confidence level. The results vary widely from method to method as shown in Table 1.

Table 1 – Summary of 100-year Peak Flow

Methodology	100-year Peak Flow (cfs)	95% Confidence (cfs)
USGS 19856	192	278
USGS 1994	334	530
USGS 2000	44	104
Averages	199	304

Hydraulic Analysis

Five cross sections were surveyed for the project. At each section, the bottom width, the maximum channel depth, and the top width at the maximum depth were measured. Elevations were also obtained, which resulted in an average channel slope of 7.5%.

It was reasoned that at the relatively high slope, that the channel flow was most likely supper critical. Therefore, for estimating capacity, critical depth was used, which results in a conservatively high flow depth.

Critical depth was then determined for each cross section for two conditions, the average peak flow for the 95% confidence level (i.e.: 304 cfs) and the maximum peak flow for the 95% confidence limit (i.e.: 530 cfs). Critical depth was determined using the graphical procedure in Chow (Chow 1959) converted to a spreadsheet format. Specific energy (i.e.: depth plus velocity head) was also calculated, as this depth provides a margin of safety or freeboard. Calculations are provided on Sheets 2 and 3 in the Appendix.

A summary of the results is presented in Table 2. The results show that the maximum depth of flow in the channel, including velocity head, is 7.2-feet. When compared to the channel depths, which range from 13- to 25-feet, there is sufficient freeboard during the 100-year event. Flow velocities are high, ranging from 9.3-fps to 11.7-fps.

Table 2 – Summary of 100-year Flow Depths

Channel Section	Critical Depth		Specific Energy	
	100-year Peak	95% Confidence	100-year Peak	95% Confidence
1	3.8	5.2	5.3	7.2
2	3.9	5.3	5.3	7.1
3	3.2	4.6	4.7	6.8
4	3.1	4.4	4.5	6.2
5	3.6	5.0	5.0	6.8
Average	3.5	4.9	5.0	6.8

References

Chow, Ven Te, 1959. *Open Channel Hydraulics.* McGraw-Hill Book Company, New York, NY.

Delorme 2004. *Topo USA.* Version 5.0

USGS 1986. *Estimation of Natural Streamflow Characteristics in Western Colorado.* Water-Resources Investigation report WRI 85-4086

USGS 1994. *Methods for Estimating Magnitude and Frequency of Floods in Southwestern United States.* Open File Report 93-419

USGS 2000. *Analysis of the Magnitude and Frequency of Floods in Colorado.* Water-Resources Investigation report WRI 99-4190

Enclosures

Figure 1 – Sharrard Creek Watershed

Calculation Appendix, 3-sheets.

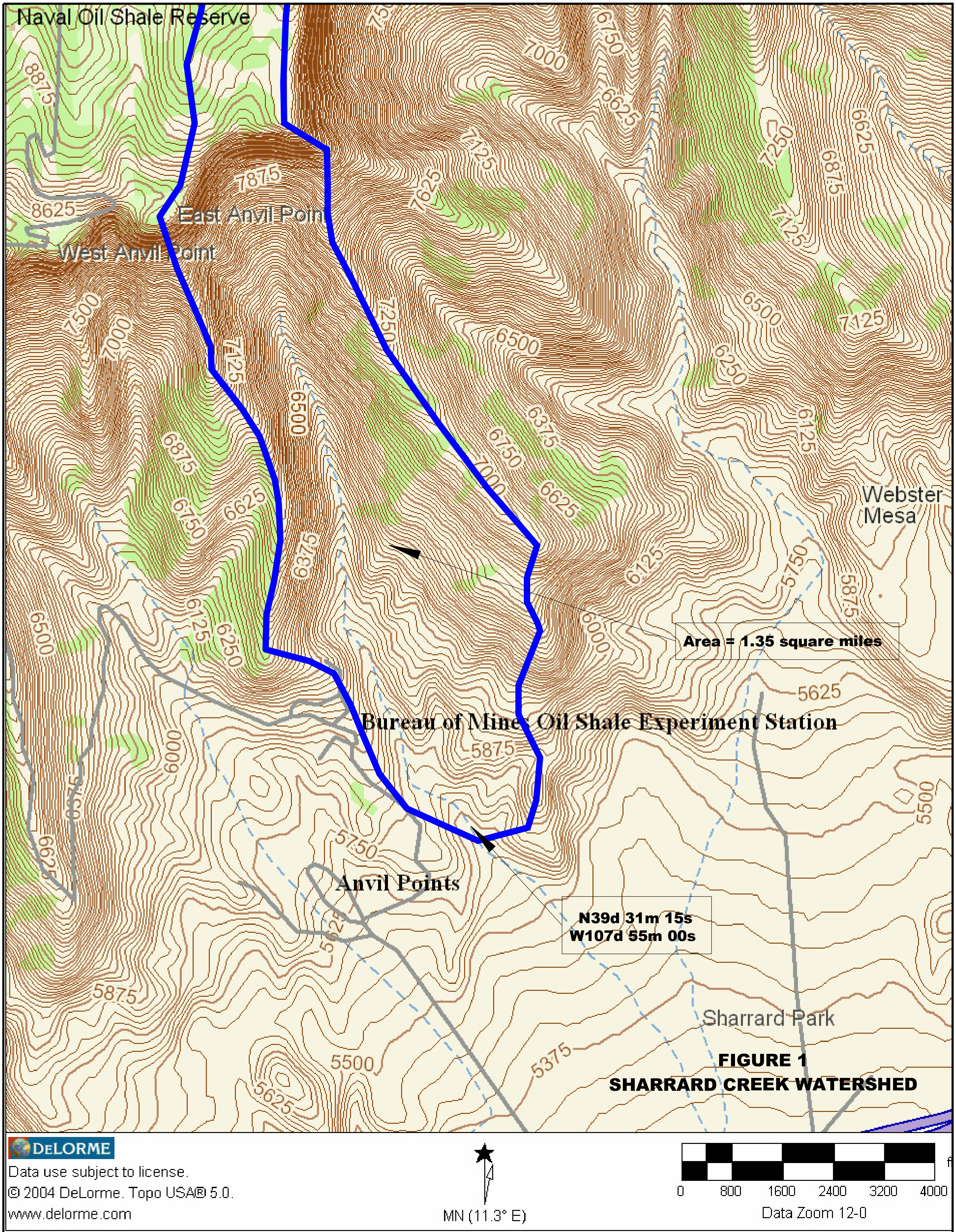

FIGURE 1
SHARRARD CREEK WATERSHED

SHARRARD CREEK AT ANVIL POINTS
HYDROLOGIC ANALYSIS

Calculate the 100-year flood peak tributary to Sharrard Creek at the shale pile, which is located at N39d 31m 15s and W107d 55m 00s

GIVEN:

Tributary watershed area =	1.35	square miles (see drainage map)
Basin length =	11660	feet
Rim elevation =	8875	feet
Outlet elevation =	5625	feet
Mean elevation =	7250	feet
So =	0.28	mean drainage basin slope, ft/ft
Po =	18.0	Mean annual precipitation

(from USGS Gage 0909300, Parachute Creek near Parachute)

METHODOLOGY:

Calculate peak flows using USGS regression equations from three sources:

1 USDI, USGS 2000. *Analysis of the Magnitude and Frequency of Floods in Colorado* Water-Resources Investigation 99-4190.

2 USDI, USGS 1994. *Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States*. Open File Report 93-419

3 USDI, USGS, 1986. *Estimation of Natural Streamflow Characteristics in* Western Colorado. Water-Resources Investigation 85-4086

Method 1:

Northwest Region (USGS 2000, Figure 1)

$Q_{100} = 39.5A^{0.706}\,(S+1)^{1.577}$

Q_{100} =	72	cfs
Standard error =	44	%
Max Q_{100} =	104	cfs

Method 2:

Flood Region No. 9 (USGS 1994, Figure 9)

$Q_{100} = 292*A^{0.444}$

Q_{100} =	334	
Standard error =	59	%
Max Q_{100} =	530	cfs

Method 3: (USGS 1986)

$Q_{100} = 98.5*A^{0.698}*E^{0.452}$

Q_{100} =	192	cfs
Standard error =	45	%
Max Q_{100} =	278	cfs

Average Values:

Q_{100} =	199	cfs
Max Q_{100} =	304	cfs

SHARRARD CREEK AT ANVIL POINTS
HYDRAULIC ANALYSIS

APPROACH:

Five cross sections were obtained along the reach of Sherrard Creek at the shale pile An elevation survey shows the creek to have a slope of about 7.5%, which will likely result in supercritical flow. Therefore, a conservative estimate of the creek capacity is to calculate the depth of flow for critical conditions.

REFERENCE:

Chow 1959. *Open Channel Hydraulics* , p69, graphical procedure
Compute Z = Q/(32.2^0.5) = 53.59
Area = (Bw + SS*Y)*Y
Hydraulic Depth, D = Area/(Bw + 2*SS*Y)
Section Factor, Z = A * (D)^0.5

GIVEN: Q_{100} = 304 cfs

CROSS SECTION DATA

Section	Bottom Width	Top Width	Depth	Avg Side Slope (XH:1V)
1	6	21	13	0.6
2	5	38	20	0.8
3	9	15	18	0.2
4	9	31	23	0.5
5	6	45	25	0.8

CALCULATED CRITICAL FLOW CONDITIONS

Procedure: Change Depth values until computed section factor, Z matches Z in cell F14
Use "tools/goal seek" and set target value to Z in Column B

Section	Depth	Area A	Hydraulic Depth D	Section Factor Z	Velocity	Velocity Head	Specific Energy
1	3.8	31.0	2.99	53.59	9.81	1.49	5.3
2	3.9	32.0	2.80	53.59	9.50	1.40	5.3
3	3.2	30.7	3.05	53.59	9.91	1.52	4.7
4	3.1	32.5	2.72	53.59	9.35	1.36	4.5
5	3.6	32.3	2.76	53.59	9.43	1.38	5.0
Average	3.5				9.6	1.4	5.0

RESULTS

The maximum flow depth for the 100-year flood peak of 300 cfs is no greater than 4-feet, with a velocity of 10-ft/s, and a maximum specific energy of less than 5.5-ft

SHARRARD CREEK AT ANVIL POINTS
HYDRAULIC ANALYSIS

APPROACH:

Five cross sections were obtained along the reach of Sherrard Creek at the shale pile
An elevation survey shows the creek to have a slope of about 7.5%, which will likely result in supercritical flow. Therefore, a conservative estimate of the creek capacity is to calculate the depth of flow for critical conditions.

REFERENCE:

Chow 1959. *Open Channel Hydraulics* , p69, graphical procedure
Compute Z = Q/(32.2^0.5) = 93.48
Area = (Bw + SS*Y)*Y
Hydraulic Depth, D = Area/(Bw + 2*SS*Y)
Section Factor, Z = A * (D)^0.5

GIVEN: Q_{100} = 530 cfs

CROSS SECTION DATA

Section	Bottom Width	Top Width	Depth	Avg Side Slope (XH:1V)
1	6	21	13	0.6
2	5	38	20	0.8
3	9	15	18	0.2
4	9	31	23	0.5
5	6	45	25	0.8

CALCULATED CRITICAL FLOW CONDITIONS

Procedure: Change Depth values until computed section factor, Z matches Z in cell F14
Use "tools/goal seek" and set target value to Z in Column B

Section	Depth	Area A	Hydraulic Depth D	Section Factor Z	Velocity	Velocity Head	Specific Energy
1	5.234	47.21	3.92	93.48	11.2	1.96	7.19
2	5.271	49.28	3.60	93.48	10.8	1.80	7.07
3	4.622	45.16	4.28	93.48	11.7	2.14	6.76
4	4.386	48.67	3.69	93.48	10.9	1.84	6.23
5	4.992	49.39	3.58	93.48	10.7	1.79	6.78
Average	4.9				11.1	1.9	6.8

RESULTS

The maximum flow depth for the 100-year flood peak of 530 cfs is no greater than 5.5-feet, with a velocity of 12-ft/s, and a maximum specific energy of less than 7.5-ft